

Exelon Generation  
200 Exelon Way  
KSA3-N  
Kennett Square, PA 19348

Telephone 610.765.5661  
Fax 610.765.5545  
www.exeloncorp.com

Project No.: 713

July 22, 2002

U.S. Nuclear Regulatory Commission  
Attn: Document Control Desk  
Washington, D.C. 20555

Subject: Submittal of Pebble Bed Modular Reactor US Pre-application Review  
Activities Summary

Exelon Generation Company (EGC), LLC and the US NRC conducted a series of Pebble Bed Modular Reactor (PBMR) pre-application review meetings and exchanged correspondence regarding technical, safety and policy issues with the mutual expectation that these activities would lead to an effective and efficient PBMR US license application and subsequent regulatory review. EGC announced on April 16, 2002, that it was withdrawing from the PBMR project and on May 16, 2002, representatives of EGC and the NRC met to discuss the closure of the pre-application review activities. As committed to in this meeting, attached is a complete summary of pre-application review activities and correspondence between EGC and the NRC, spanning the period from December 2000 through June 2002.

The NRC also issued letters dated April 2, 2002, June 3, 2002, June 27, 2002, and two letters dated May 31, 2002 requesting additional information pertaining to the PBMR. The NRC request for additional information (RAI) letters capture questions raised by the NRC during some of the PBMR pre-application review discussions, and formally documents the results of the NRC's review to date regarding topical papers submitted by EGC. Some of the questions were answered in part, during the PBMR discussions or via the EGC topical papers. However, the majority of the NRC questions would require substantial resources to answer or cannot be answered at this time due to the ongoing development of the PBMR design. Therefore, in keeping with the closure objective presented at the May 16, 2002, meeting to minimize costs and the need for any additional work, we have decided not to provide any further responses to the above cited RAIs. Instead, we have identified the RAIs in the attached summary as they pertain to the key administrative, technical and policy issues.

The information contained in this summary is not being provided to the NRC for review or comment. Rather this information is being provided as a guide that would benefit the NRC and potential future PBMR applicants if PBMR pre-licensing activities were to resume.

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If you have any questions or concerns regarding this matter, please contact R. M. Krich or me.

Sincerely,

A handwritten signature in black ink, appearing to read "Kevin F. Borton", written over a horizontal line.

Kevin F. Borton  
Manager, Licensing

Attachment

cc: Farouk Eltawila, Office of Nuclear Reactor Research  
James Lyons, Office of Nuclear Reactor Regulation  
Amy Cubbage, Office of Nuclear Reactor Regulation  
Stuart Rubin, Office of Nuclear Reactor Research

bcc: E. Cullen  
R. Krich  
M. Magugumela (PBMR, South Africa)  
T. Rudek (Westinghouse)

Correspondence Control Desk - KSA 1-N  
02-17013  
DAC - KSA 1-N

**Attachment**

**"Pebble Bed Modular Reactor Pre-application Review Activities Summary"**

**Exelon Generation Company, LLC**

**Submitted July 22, 2002**

**31 Pages**

**Exelon Generation Company, LLC**

**Pebble Bed Modular Reactor Pre-application Review**

**Activities Summary**

The purpose of this document is to summarize meetings and correspondence between Exelon Generation Company (EGC), LLC and the US NRC regarding Pebble Bed Modular Reactor (PBMR) pre-application activities. EGC acknowledges the effort and benefit provided by the NRC's substantial involvement in the PBMR pre-application activities. The exchange of information has advanced the understanding of licensing the PBMR design in the US, and should enhance the effectiveness and efficiency in the eventual preparation and NRC review of an application. The following summary of pre-application review areas provides a brief description of key issues, identification of meetings and correspondence, and provides a brief status or the feedback communicated by the EGC and/or the NRC regarding the issue at the close of EGC's pre-application efforts. EGC has decided, based on a review of the NRC requests for information, that responses will not be provided at this time in keeping with the pre-application review closure objectives of minimizing cost and reducing the need for additional information. The following information covers the pre-application review period from December 2000 through June 2002.

**Area 1 –Approach to US Licensing of a PBMR**

Preparing a combined construction permit and operating license (i.e., COL) application in accordance with 10 CFR 52, “ Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants,” had not previously been attempted. Implementation details, applicant and NRC resource requirements, and process durations were unknown. In addition, the PBMR is a high temperature, gas-cooled, graphite

moderated reactor. Much of the current US NRC regulations and guidance is based on light water reactor (LWR) experience.

Sequencing:

Two of the elements of 10 CFR 52 (i.e., Early Site Permits (ESP) and a COL) have not been exercised in their entirety or in combination.

- EGC letter dated December 5, 2000, “Pebble Bed Modular Reactor Review Requirements,” described EGC’s intent to interact with the NRC to explore how EGC could efficiently proceed with licensing the PBMR, which will help determine if the PBMR is a viable project for the United States.
- EGC meeting with the NRC on April 30, 2001 provided a description of the PBMR project and plans for further pre-application activities.
- EGC letter dated May 25, 2001, “Pebble Bed Modular Reactor (PBMR) 10 CFR Part 52 Applications and Licensing Plan,” described EGC’s proposed plan sequence, timing, and duration regarding each 10 CFR 52 element and asked for the NRC’s view regarding the proposal.
- NRC letter dated August 23, 2001 from S. J. Collins to J. A. Muntz - Vice President, Nuclear Projects EGC, provided the NRC’s preliminary view on the proposed licensing sequence as conceptually acceptable and in accordance with the processes set forth in 10 CFR 52.
- NRC SECY 01-0188, “Future Licensing and Inspection Readiness Assessment (FLIRA),” dated October 12, 2001, provided a readiness statement along with NRC resource and schedule estimates regarding new plant licensing activities.

EGC’s licensing strategy for an initial US facility was to obtain an ESP, a COL, and following operation of the initial facility, a Design Certification (DC) for the PBMR design. EGC’s schedules and proposed durations were based on EGC’s proposed plan to construct and operate a merchant plant facility having the first module operational by

2008. The EGC proposed durations of each 10 CFR 52 element (i.e., ESP, COL, and DC) that were consistent with NRC regulations and were perceived to be achievable.

The NRC found the proposed licensing sequencing conceptually acceptable and in accordance with the licensing processes set forth in 10 CFR 52 (e.g., COL preceding a DC). However, the NRC indicated that several multi-module and merchant plant concerns were noted such as the duration of a single combined license for a multi-module facility, prototype testing requirements for a COL similar to a DC, annual fees, and financial protection. These issues will be discussed in detail in the following sections (i.e., Area 2, and Area 12). NRC SECY 01-0188 concluded that 10 CFR 52 is ready to be used; however, the NRC estimated review and approval durations, regardless of design type, for the COL and DC elements greatly exceeded EGC estimate for those elements.

#### Licensing Approach:

Currently there is not a separate US regulatory framework for gas-cooled reactors. Much of the current regulations, review plans, and NRC guidance are based on LWR experience.

- EGC meeting with the NRC on June 12, 2001 provided the NRC with EGC's proposed risk-informed licensing approach based on an earlier US Department of Energy (DOE) Modular High Temperature Gas-cooled Reactor (MHTGR) approach.
- NRC letter dated June 25, 2001 from T. L. King to K. F. Borton - Licensing Manager, EGC, requested that EGC assess a sample of NRC identified regulations using the EGC licensing approach in order to better understand the proposed approach.
- EGC meeting with the NRC on July 17, 2001 provided a detailed description of the licensing approach process for the selection of PBMR licensing basis events.
- EGC meeting with the NRC on August 9, 2001 presented the preliminary results of screening current regulations using the licensing approach, including the requested samples contained in NRC letter dated June 25, 2001 above.

- NRC letter dated August 16, 2001 from T. L. King to K. F. Borton - Licensing Manager, EGC, provided NRC's early comments regarding the EGC licensing approach.
- EGC meeting with NRC on August 15, 2001 provided the remaining details of the EGC licensing approach including the selection of safety related systems, structures, and components.
- EGC letter dated August 31, 2001, "Proposed Licensing Approach for the PBMR in the United States," was submitted to the NRC for review and comment.
- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated November 15, 2001, "Response to NRC letter dated September 26, 2001, Regarding the Pebble Bed Modular Reactor Technical Information Availability," provided additional information regarding the US licensing approach.
- EGC presentation on October 4, 2001 to the NRC Advisory Committee on Reactor Safeguards (ACRS) provided the EGC licensing approach for ACRS discussion.
- EGC letter dated January 31, 2002, "Revision of Exelon Generation Company's Proposed Licensing Approach for the Pebble Bed Modular Reactor in the United States," identified the preliminary PBMR licensing basis events determined by the preliminary PBMR Probabilistic Risk Assessment (PRA) results.
- EGC letter dated March 15, 2002, "Revision of Exelon Generation Company's Proposed Licensing Approach for the Pebble Bed Modular Reactor in the United States," defined a set of preliminary safety significant PBMR systems, structures, and components (SSCs) determined by the preliminary PBMR PRA results.
- NRC letter dated March 26, 2002 from F. Eltawila to K. F. Borton – Licensing Manager, EGC, provided the NRC's preliminary assessment of EGC's proposed licensing approach.
- NRC letter dated June 3, 2002, "Request for Additional Information (RAI) Related to Exelon's March 15, 2002, Document Titled 'Proposed Licensing Approach for the Pebble Bed Modular Reactor (PBMR) in the United States,'" provided the NRC's

open issues and requests toward obtaining a more in-depth understanding of the EGC proposed process.

The above identified correspondence can be summarized as follows. EGC recognized that earlier high temperature gas-cooled nuclear plants (e.g., Fort Saint Vrain, Peach Bottom Unit 1) were licensed utilizing existing regulations, and that new regulatory tools (e.g., PRA) were available which would help navigate a gas-cooled design review within the current regulatory framework. EGC presented a method to license the PBMR within the current regulatory framework and included discussions regarding the methods for meeting the NRC's Advanced Reactor Policy, and incorporating the defense-in-depth philosophy into the design and operation of a PBMR. The NRC concluded that the licensing approach proposed by EGC, if adequately implemented, is a reasonable process for ensuring that the NRC's regulations are met and for identifying new PBMR-specific regulatory requirements. The NRC stated that the process provides a structured approach for identifying events to be considered in the design, their acceptance criteria and safety classification of SSCs, utilizing plant specific risk information. However, the NRC also provided some caveats and identified some potential NRC policy issues in their March 26, 2002 letter.

The NRC issued a request for additional information describing open issues and information requests in order to obtain a more in depth understanding of the process and its implementation. Since much of the requested information contained in the NRC RAI would be better addressed following completion of the PBMR final design and would rely on the outcome the PBMR PRA, which is still preliminary, EGC has decided not to provide a response at this time to the NRC requests contained in the June 3, 2002 RAI.

## **Area 2 – Merchant, Multi-module Plant Licensing**

### Price-Anderson Act:

The Price-Anderson Act imposes certain financial protection requirements on each licensee of a nuclear “facility,” which includes a maximum retrospective premium of almost \$90 million in the event of a nuclear incident involving a nuclear plant in the United States. NRC’s implementing regulation (i.e., 10 CFR 140.11 “Amounts of financial protection for certain reactors”) imposes these requirements on each “nuclear reactor,” so that a PBMR licensee would be liable for a maximum retrospective premium of nearly \$90 million per module. If the NRC were to impose this requirement on each module, a 10-module PBMR nuclear facility would have a potential liability of almost \$900 million. This amount is greatly disproportionate to the potential liability for other reactor facilities of similar size, and runs counter to the intent of the Price-Anderson Act in spreading the risk of liability across the industry.

- EGC letter dated May 10, 2001, “Regulatory Issues Related to the Pebble Bed Modular Reactor,” provided nine white papers regarding legal and financial issues, including Price-Anderson Act financial protection.
- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 20, 2001, outlined NRC’s preliminary position regarding EGC’s white papers and NRC-identified related issues.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feedback on NRC SECY-01-0207.

EGC proposed that the NRC should treat multi-module plants as one “facility” under the Price-Anderson Act, and an early applicant would request an exemption from the NRC regulation for the initial facility while the industry (i.e., the Nuclear Energy Institute (NEI)) and the NRC pursued rulemaking which would treat a multiple module site as a single facility.

The NRC indicated that there are substantial doubts whether the NRC has the authority to treat multi-module reactor plants as one facility, and would approve exemptions for that purpose. The US House of Representatives has passed a bill proposing to amend the Price-Anderson Act treating multiple module nuclear plants up to 1300 MWe as a single facility. The NRC's position is that rulemaking would be required and the exact nature and scope of the rulemaking would be decided later depending on the language approved by Congress.

#### NRC Fees:

10 CFR 171.15 “Annual fees: Reactor licenses and independent spent fuel storage licenses,” paragraph (a) states that each person licensed to operate a power reactor shall pay an annual fee “for each unit for each license” held at any time during the Federal fiscal year in which the fee is due. If each PBMR module is treated as a separately licensed reactor, Section 171.15 could be construed so as to impose a separate fee for each module. Therefore, the annual fee for a 10-module PBMR would be greatly disproportionate to the annual fee for an equivalent sized boiling water reactor (BWR) or pressurized water reactor (PWR). This administrative issue could place a modular reactor design at a competitive disadvantage with other designs and act as a disadvantage to the development of modular reactors in general.

- EGC letter dated May 10, 2001, “Regulatory Issues Related to the Pebble Bed Modular Reactor,” provided nine white papers regarding legal and financial issues, including NRC fees for multi-module plants.
- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 20, 2001, outlined NRC’s preliminary position regarding EGC’s white papers and NRC-identified related issues.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feedback on NRC SECY-01-0207.

- NEI meeting with the NRC on May 22, 2002 addressed the NRC's modular licensing preliminary positions contained in SECY 01-0207, and NEI presented alternative options.
- NEI position paper submitted to the NRC by letter dated June 17, 2002, from R. L. Simard to J. E. Lyons - Director, NRC New Reactor Licensing Project Office, proposed an integrated multi-module licensing concept with a single annual 10 CFR 171 NRC fee.

EGC proposed to initiate 10 CFR 171 rulemaking to specify that only one annual fee will be required for each multi-module facility. The NRC stated that power plant cost must be assessed in a "fair and equitable" manner, and "to the maximum extent practicable," reflect a "reasonable relationship" between fees charges and the services rendered. If NRC PBMR regulatory oversight efforts and the magnitude of NRC resources required are different from current plants, a separate class of licensees could be established. Consistent with current practices, the NRC plans to assess annual fees only after construction has been complete, all regulatory requirements have been met, and the reactor(s) is authorized to operate. However, until sufficient information regarding NRC regulatory oversight requirements and how the NRC decides to issue licenses for multi-module facilities, no NRC recommendation is being made regarding a new license fee category for modular reactors.

#### Type of License for a Multiple Module Facility:

The NRC could issue individual COLs for each reactor module of a multi-modules facility, or could issue a single COL that covers the entire facility (i.e., all reactors). However, determining the number of licensing reviews and hearings conducted by the NRC, the permitted operating duration of the license, the mechanism to assess annual NRC fees, and consideration of a Price-Anderson Act retrospective premium based on a single facility license or multiple licenses requires an integrated approach to ensure multi-

module facilities are not unfairly burdened by these NRC administrative requirements compared to single reactor designs.

- EGC letter dated May 10, 2001, “Regulatory Issues Related to the Pebble Bed Modular Reactor,” provided nine white papers regarding legal and financial issues, including type of license for a multi-modular facility.
- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 20, 2001, outlined NRC’s preliminary position regarding EGC’s white papers and NRC-identified related issues.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feedback on NRC SECY-01-0207.
- NEI meeting with the NRC on May 22, 2002 addressed the NRC’s modular licensing preliminary positions contained in SECY 01-0207, and NEI presented alternative options.
- NEI position paper submitted to the NRC by letter dated June 17, 2002, from R. L. Simard to J. E. Lyons - Director, NRC New Reactor Licensing Project Office, proposed an integrated multi-module licensing concept involving separate modular COLs, one for each reactor at a facility.

The NRC outlined concerns and conflicts with both a single facility license and multiple licenses for a multi-module facility. NEI presented a concept which lays out a feasible approach to resolve the NRC’s and the industry’s concerns while establishing a structured, efficient process to license multi-module facilities under 10 CFR 52. EGC helped develop and concurs with the NEI integrated multi-module licensing concept contained in NEI letter dated June 17, 2002. The NRC has not commented on the NEI June 17, 2002 letter as of the date of this document.

In addition to the EGC identified issues, the NRC in SECY 01-0207 identified three other multi-module licensing related issues (i.e., license duration, duration of design approval, and, as described above, commencement of the requirement to pay annual fees).

EGC's and NEI's position is that a COL should have a 40-year life, beginning with the issuance of the NRC's 10 CFR 52.103 "Operation under a combined license," paragraph "(g)" finding. As described in the June 17, 2002 NEI proposal, the 40-year operating license term is similar to proposed language currently in legislation being considered by both houses of Congress, and would alleviate the burden of modular plants having to seek license renewal in order to reach a nominal 40-year operating life. The NRC has stated that further consideration should be given to the possible issuance of one COL for multiple reactor modules, as it relates to the effective duration of a design approval. However, the NRC has raised the issue of whether the 'n'th module at a multiple module facility be allowed to be built a substantial number of years after issuing of the first module license without reconsidering the acceptability of the original design. The NEI proposal provides a process that assures that all safety and environmental issues can be addressed and allows each module to achieve a full 40-year operating life similar to single reactor designs.

EGC and NEI contend that the duration of COL design approval for a multi-module facility licensed under 10 CFR 52 is 40 years. Furthermore, there are currently sufficient regulatory provisions available to the NRC so that any new safety and environmental issues would be addressed regarding the operating modules and modules under construction as they would for a single operating or under construction reactor facility. NRC is concerned that safety issues may arise after gaining experience resulting from operation of the initial modules at a facility. The addition of new regulatory requirements to periodically re-review the design approval for a COL that have multi-modules is an unnecessary burden. The NRC refers to the periodic design reviews required of design certification and manufacturing licenses; however, these provisions do not have the same regulatory constraints that apply to a COL. The regulations under 10 CFR 52 for modules pending construction and operation at a single facility, and under 10 CFR 50, "Domestic Licensing of Production and Utilization facilities," for the operating modules currently provide the ability to address any potential safety issues in accordance with 10 CFR 109,

"Backfitting." The NRC has not commented on the industry proposal contained in the June 17, 2002 NEI letter, which address the NRC's concerns and outlines a potential solution.

#### Decommissioning Funding:

10 CFR 50.75, "Reporting and recordkeeping for decommissioning planning," requires licensees to establish financial assurance for decommissioning. Section 50.75(e)(1) provides six methods for providing financial assurance. These methods include prepayment, an external sinking fund, surety, insurance, or other "equivalent" methods. However, Section 50.75(e)(1) essentially restricts use of external sinking funds to licensees that recover decommissioning funds through regulated electricity rates or a non-bypassable charge.

- EGC letter dated May 10, 2001, "Regulatory Issues Related to the Pebble Bed Modular Reactor," provided nine white papers regarding legal and financial issues, including PBMR decommissioning funding.
- NRC SECY-01-0207, "Legal and Financial Issues Related to Exelon's Pebble Bed Modular Reactor," dated November 20, 2001, outlined NRC's preliminary position regarding EGC's white papers and staff-identified related issues.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feedback on NRC SECY-01-0207.
- NEI meeting with the NRC on May 22, 2002 addressed the NRC's modular licensing preliminary positions contained in SECY 01-0207, and NEI presented alternative options.
- NEI position paper submitted to the NRC by letter dated June 17, 2002, from R. L. Simard to J. E. Lyons - Director, NRC New Reactor Licensing Project Office addresses decommissioning assurance methods.

EGC initially proposed to exercise the "equivalent" provision under 10 CFR 50.75(e).

EGC and NEI put forth a proposal of an alternate funding mechanism that provides for partial prepayment of the decommissioning cost and annual contributions for the remainder spread over 20 years that would meet project financial viability goals. The NRC has stated that such an alternative would not be consistent with the regulations and that it would be difficult to justify as an exemption for a merchant facility. The NRC interprets 10 CFR 50.75(e) to allow a 2-percent real earnings credit, and suggested that the present value of the decommissioning cost would not be large. EGC contends that the initial cost for any merchant plant design would significantly impact industry financial viability goals for new plant construction. Both EGC and the NRC concur that decommissioning funding requirements could be achieved by a corporate parent guarantee under the current regulation and NEI is currently evaluating various mechanisms, such as the industry insurance consortium, that could provide the necessary guarantee. The NRC also stated that no new rulemaking is planned.

#### Decommissioning Costs:

10 CFR 50.75(c) specifies a minimum amount for the decommissioning fund for BWRs and PWRs. However, this section does not specify a minimum amount for the projected decommissioning fund for a gas-cooled reactor.

- EGC letter dated May 10, 2001, “Regulatory Issues Related to the Pebble Bed Modular Reactor,” provided nine white papers regarding legal and financial issues, including estimating decommissioning costs for a PBMR facility.
- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 20, 2001, outlined the NRC’s preliminary position regarding EGC’s white papers and staff-identified related issues.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feed back on NRC SECY-01-0207.

EGC proposed that the COL application would include a cost estimate for decommissioning a PBMR facility. The NRC indicated a willingness to accept a minimum decommissioning cost estimate specifically for the PBMR, if the NRC finds the technical justification to be adequate.

Anti-Trust:

Section 105 of the Atomic Energy Act (AEA) requires that the NRC conduct an antitrust review, seek the advice of the Attorney General, and if necessary conduct a hearing on antitrust matters in connection with applications for a construction permit (CP) or a COL for a nuclear power reactor. NRC's implementing regulations in 10 CFR 50.33a, "Information requested by the Attorney General for antitrust review," provide that applicants for such licenses are required to submit to the NRC detailed transmission, distribution, and business planning information that will allow the Attorney General of the United States and NRC to conduct an antitrust review of the proposed project. Pursuant to Section 105(c)(7) of the AEA, NRC has the authority, with the approval of the Attorney General, to determine that issuance of certain classes of licenses would not significantly affect the licensees' activities under the antitrust laws, and therefore exempt such applicants from NRC antitrust review under Section 105. Recognizing the current status of competition in the electricity provider industry and the fundamental competitive realities surrounding the operation of any new merchant nuclear project, the NRC should make a determination under Section 105(c)(7) that applicants that will operate their plants as merchant plants are exempted from NRC antitrust review.

- EGC letter dated May 10, 2001, "Regulatory Issues Related to the Pebble Bed Modular Reactor," provided nine white papers regarding legal and financial issues, including position regarding Anti-trust reviews for merchant plant applicants.
- NRC SECY-01-0207, "Legal and Financial Issues Related to Exelon's Pebble Bed Modular Reactor," dated November 20, 2001, outlined the NRC's preliminary position regarding EGC's white papers and NRC-identified related issues.

- NRC workshop was held on March 27, 2002 seeking additional stakeholder feed back on NRC SECY-01-0207.

EGC's position is that the NRC should initiate a proceeding, and seek the approval of the Attorney General, to determine that the issuance of licenses to merchant plant applicants will not significantly affect such applicants' activities under the antitrust laws. NRC should make a determination pursuant to Section 105(c)(7) that merchant plant applicants are exempted from antitrust review. Any such determination should also provide appropriate criteria for determining whether an applicant qualifies as a merchant plant operator. The NRC should also initiate a rulemaking to clarify that its rules do not require that a merchant plant applicant submit the antitrust information identified in 10 CFR 50.33a. The rule should state that an applicant need only provide information sufficient for the NRC to make a determination as to whether the applicant qualifies as a member of the exempted class. The NRC has stated that its ability to exempt certain applicants for new generating facilities from the NRC's antitrust review requirements is being addressed separately by the NRC Office of the General Council.

#### Operator Staffing:

10 CFR 50.54 "Conditions of a license," paragraph "(m)," specifies minimum licensed operator staffing requirements. However, it does not identify staffing requirements for sites with more than two units with a common control room. Moreover, Section 50.54(m) contains requirements on the location of operators; i.e., it requires that one senior reactor operator (SRO) be in the control room of a unit during operation, that one reactor operator (RO) be at the controls for each unit during operation, and that an SRO be present during fuel handling. If NRC were to treat each PBMR module as a separate unit, the staffing requirements in Section 50.54(m) would be excessive and unnecessary.

- EGC letter dated May 10, 2001, “Regulatory Issues Related to the Pebble Bed Modular Reactor,” provided nine white papers regarding legal and financial issues, including proposed staffing requirements.
- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 29, 2001, outlined the NRC’s preliminary position regarding EGC’s white papers and NRC-identified related issues.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feedback on NRC SECY-01-0207.

EGC's position is that the license application will justify operator staffing requirements and request an exemption from 10 CFR 50.54(m). The NRC agreed that the application must provide adequate justification for staffing levels and justify that more than two reactors can be adequately controlled from one control room. This should include a function and task analysis, followed by performance demonstrations on a control room simulator or control room prototype.

#### Fuel Cycle and Transportation:

10 CFR 51.51, “Uranium fuel cycle environmental data – Table S-3,” and 10 CFR 51.52, “Environmental effects of transportation of fuel and waste –Table S-4,” specify the environmental impacts attributable to the fuel cycle and transportation for LWRs but not for other types of reactors. As a result, this issue is unresolved for the PBMR.

Additionally, 10 CFR 51.23, “Temporary storage of spent fuel after cessation of reactor operation – generic determination of no significant environmental impact,” identifies provisions to dispose of the spent fuel (i.e., the “waste confidence” rule).

- EGC letter dated May 10, 2001, “Regulatory Issues Related to the Pebble Bed Modular Reactor,” provided nine white papers regarding legal and financial issues, including treatment of fuel cycle impacts regarding the PBMR.

- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 20, 2001, outlined the NRC’s preliminary position regarding EGC’s white papers and NRC-identified related issues.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feedback on NRC SECY-01-0207.
- NEI position paper submitted to the NRC by letter dated June 17, 2002, from R. L. Simard to J. E. Lyons - Director, NRC New Reactor Licensing Project Office, identifies an NRC clarification regarding fuel-shipping casks.

EGC’s position is that the license application will identify the environmental impacts attributable to the fuel cycle and transportation for a PBMR facility. The NRC agrees that the application must include design-specific environmental impacts. However, any effort to undertake generic rulemaking on PBMR-specific fuel cycle and fuel transportation issues would be premature. The NRC agrees that a PBMR facility is within the scope of 10 CFR 51.23(a), and that a PBMR applicant should confirm that the Department of Energy facility will accept PBMR fuel. During the May 22, 2002 NEI meeting the NRC noted that there is not a regulatory requirement for an applicant to have, as part of the license application, approved fresh fuel and spent fuel casks and that the SECY-01-0207 statement will be clarified.

### **Area 3 - PBMR Fuel**

A fundamental aspect of the PBMR application is the robustness of the PBMR TRISO coated particle fuel. The production of high quality fuel is essential for ensuring the retention of fission products during both normal operating and potential accident conditions. A set of well-defined manufacturing process and quality controls is critical to the consistent production of high quality fuel.

- EGC meeting with the NRC on June 13, 2001 presented an overview of the PBMR fuel design, manufacturing, quality control and qualification.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated November 15, 2001, "Response to NRC letter dated September 26, 2001, Regarding the Pebble Bed Modular Reactor Technical Information Availability," provided additional information regarding PBMR fuel.
- EGC letter dated January 31, 2002, "Submittal of Fuel Fabrication Quality Control Measures and Performance Monitoring Plans for the Pebble Bed Modular Reactor (PBMR) Fuel," provided documentation, which complemented portions of the "PBMR Fuel Overview" presentation made on June 13, 2001.
- EGC letter dated March 18, 2002, "Document Supporting the March 28, 2002 Pre-application Meeting Regarding the Pebble Bed Modular Reactor (PBMR)," contained the technical information that complemented a planned presentation regarding the PBMR fuel qualification test program.
- EGC meeting with the NRC on March 28, 2002, presented EGC's proposed PBMR fuel qualification test program.
- NRC letter dated April 2, 2002 from Farouk Eltawila to Kevin Borton - Licensing Manager, EGC, provided the NRC's open issues and requests toward obtaining a more in-depth understanding of potential operational hazards regarding Carbon-14, Silver-110m and graphite dust.
- EGC letter dated May 24, 2002 "Submittal of the Pebble Bed Modular Reactor Pty. Document Number 010520-425, Revision 2, '*Pebble Bed Modular Reactor Nuclear Fuel*,' "provided documentation, which complements portions of the "PBMR Fuel Overview," presentation, made on June 13, 2001.
- EGC letter dated May 30, 2002, "Submittal of Historical German Fuel Qualification Process Document," provided the historical German fuel qualification process referenced in EGC's PBMR fuel qualification test plan, which was provided to the NRC by letter dated March 18, 2002.

- NRC letter dated June 27, 2002 provided the NRC's open issues and requests for information that would support a more in-depth understanding of the EGC proposed fuel licensing basis.

EGC summarized the manufacturing process for PBMR fuel, including the key fuel specifications and the quality control process. The specific parameters measured as part of the quality control process were discussed, along with methods used to measure them. PBMR fuel quality is also a function of monitoring the in-core fuel performance. The monitoring plan for fuel performance includes the methods for monitoring the core operating conditions, the detection of failed fuel in the reactor, and the determination of fuel burn-up levels. Finally EGC described the fuel qualification test program for TRISO-coated particle fuel in support of planned efforts directed toward the licensing of the PBMR. The PBMR COL licensing basis would include fuel material and performance specifications to be met by PBMR fuel, as well as reactor operational performance specifications (e.g., allowed circulating activity in the primary system). The design and fabrication process for PBMR fuel would be based directly on substantial German experience fabricating Low Enriched Uranium (LEU)  $\text{UO}_2$  coated particle fuel. A large body of international fuel test data and plant operating experience exists in support of the establishment of performance criteria for PBMR fuel under normal and accident conditions. The data and experience developed within the German program constitute the largest and most directly relevant body of information. Additional data and experience from China, Japan, and Russia complement the German information and expand its applicability. These data constitute proof of principle for the  $\text{UO}_2$  coated particle fuel form and, in conjunction with PBMR plant safety analyses and information developed regarding the PBMR fuel production process, would form the basis for the fuel specification contained in the PBMR COL application.

The NRC had not provided specific findings regarding EGC's proposed US fuel licensing basis; however, the NRC provided guidance in the form of open issues and requests for clarity of EGC's proposed fuel licensing basis. As explained above, EGC will not

respond to the NRC RAI contained in the NRC letters dated April 2, 2002 and June 27, 2002.

#### **Area 4 - Analytical Codes**

Analytical tools would be used to assess the PBMR plant responses to accident conditions. These tools and plans for validation would need to be reviewed by the NRC. Some of the tools developed by German and South African designers may be unfamiliar to the NRC; therefore, early NRC review would be required to ensure an efficient application review.

- EGC meeting with the NRC on August 16, 2001 provided a preliminary description of the analytical codes used by the PBMR designers.
- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated October 30, 2001, "Summary of Pre-application Presentations Regarding the Pebble Bed Modular Reactor (PBMR)," provided a data table containing analytical computer codes identified during the August 16, 2001 presentation.
- NRC letter dated May 31, 2002, "Requests for Additional Information (RAI) on Analytical Codes and Software Control; Core Design and Heat Removal and; Operational Modes and States for the Pebble Bed Modular Reactor (PBMR)," provided the NRC's open issues and requests toward obtaining a more in-depth understanding of the PBMR analytical computer codes.

The NRC did not provide specific findings regarding PBMR analytical codes; however, the NRC provided guidance in the form of open issues and requests for clarity of PBMR analytical computer code programs. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated May 31, 2002.

## **Area 5 - Core Design and Heat Removal**

The following meetings and correspondence between EGC and the NRC were intended to familiarize the NRC reviewers with the PBMR core design and core heat removal systems.

- EGC meeting with the NRC on July 18, 2001 provided an overview of the preliminary PBMR core design and heat removal systems.
- EGC letter dated March 5, 2002, “Withdraw and Re-submittal of the Pebble Bed Modular Reactor Core Design and Heat Removal Presentation Material and the Design and Heat Removal Preliminary Description Document,” provided information pertaining to the PBMR core design and heat removal systems.
- NRC letter dated May 31, 2002, “Requests for Additional Information (RAI) on Analytical Codes and Software Control; Core Design and Heat Removal and; Operational Modes and States for the Pebble Bed Modular Reactor (PBMR),” provided the NRC’s open issues and requests toward obtaining a more in-depth understanding of the PBMR analytical computer codes.

The NRC did not provide specific findings regarding the PBMR design; however, the NRC provided guidance in the form of open issues and requests for clarity of PBMR’s core design, heat removal, and safe shut down features. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated May 31, 2002.

## **Area 6 – Codes and Standards**

In order for the NRC to prepare for and review the PBMR US licensing application, the NRC needed an understanding of design codes and standards used by the PBMR designers.

- EGC meeting with the NRC on July 18, 2001 provided a preliminary list of the construction and material codes and standards
- EGC letter dated October 30, 2001, “Summary of Pre-application Presentations Regarding the Pebble Bed Modular Reactor (PBMR),” contained a preliminary description of the PBMR design codes and standards.
- NRC letter dated May 31, 2002, “Requests for Additional Information (RAI) on High Temperature Materials Graphite; Control of Chemical Attack; and Design Codes and Standards for the Pebble Bed Modular Reactor (PBMR),” provided the NRC’s open issues and requests toward obtaining a more in-depth understanding of the PBMR.

The EGC presentation provided the NRC staff with an understanding of the design codes and standards and other regulatory/ industry guidance being used or being considered for use, in the design of the PBMR. EGC and the PBMR project organization performed a US guidance assessment comparing the current PBMR design against the NRC standard review plan acceptance criteria. The results of the assessment are available for NRC review; however, the results were not submitted to the NRC, nor have the results be reviewed by the NRC.

The NRC did not provide specific findings regarding the PBMR design codes and standards; however, the NRC provided guidance in the form of open issues and requests for clarity of PBMR’s design codes and standards. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated May 31, 2002.

## **Area 7 – High Temperature Material**

The following meetings and correspondence between EGC and the NRC were intended to familiarize the NRC reviewers with the high temperature materials selected for the preliminary PBMR design.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated October 23, 2001, "Documents Supporting the October 25, 2001 Pre-application Meeting Regarding the Pebble Bed Modular Reactor (PBMR)," provided information pertaining to the PBMR high temperature graphite material.
- EGC meeting with the NRC on October 25, 2001 provided a description of the PBMR high temperature components and structures including the graphite reactor core reflector, and specified material properties.
- EGC letter dated October 30, 2001, "Summary of Pre-application Presentations Regarding the Pebble Bed Modular Reactor (PBMR)," contained information regarding material selection and service conditions related to the reactor pressure vessel.
- EGC letter dated March 5, 2002, "Withdraw and Re-submittal of the Pebble Bed Modular Reactor Core Design and Heat Removal Presentation Material and the Design and Heat Removal Preliminary Description Document," provided information pertaining to the PBMR design temperatures during normal and design accident conditions.
- NRC letter dated May 31, 2002, "Requests for Additional Information (RAI) on High Temperature Materials Graphite; Control of Chemical Attack; and Design Codes and Standards for the Pebble Bed Modular Reactor (PBMR)," provided the NRC's open issues and requests for information supporting a more in-depth understanding of the PBMR.

The EGC presentation provided the NRC staff with an understanding of the materials that will be used in high temperature applications, and their properties.

The NRC did not provide specific findings regarding the PBMR material selection; however, the NRC provided guidance in the form of open issues and requests for clarity

of the PBMR high temperature material applications. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated May 31, 2002.

### **Area 8 – Control Room Design**

The PBMR multi-module facility, having up to ten reactors, is designed to be operated from one control room. This is a departure from current LWR design. The PBMR passive design will also result in the review of unique design features such as control room layout strategy for operation (i.e., operator roles during normal and accident conditions), requirements for remote shutdown, and instrument and control system requirements.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.

EGC provided only conceptual discussions of the PBMR control room layout during initial plant presentations to the NRC since much of the multi-module design and control room operator roles were still under development. The NRC did not provide specific findings regarding the control room design concept.

### **Area 9 – Security and Safeguards**

The PBMR's passive safety features, routine re-circulation of fuel and online fueling and defuelling capabilities could pose new and unique security and safeguards questions that needed to be addressed.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.

- EGC letter dated November 15, 2001, “Response to NRC letter dated September 26, 2001, Regarding the Pebble Bed Modular Reactor Technical Information Availability,” provided additional information regarding PBMR fuel handling.
- NRC letter dated April 2, 2002 from Farouk Eltawila to Kevin Borton - Licensing Manager, EGC, provided the NRC’s request for the timing when additional security and safeguard information would be available.
- EGC letter dated June 6, 2002, “Submittal of Preliminary Safeguards Criteria Regarding the Pebble Bed Modular Reactor,” provided the International Atomic Energy Agency’s (IAEA’s) preliminary view regarding the PBMR design’s proliferation resistance.

EGC did not provide PBMR security and safeguards descriptions to the NRC during the pre-application review activities since much of the multi-module design and fuel handling details were still being developed. EGC’s preliminary assessment of the PBMR is that security and safeguards would not pose any unique regulatory concern. No issues specifically related to security design aspects to protect against terrorist actions were discussed by EGC or the NRC regarding the PBMR. The NRC did not provide any specific findings regarding PBMR security and safeguards issues. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated April 2, 2002.

#### **Area 10 – PBMR Source Term**

The PBMR plant design and fuel design requires design specific radiological source terms to be included in the basis for the PBMR safety analysis.

- EGC letter dated August 31, 2001, “Proposed Licensing Approach for the PBMR in the United States,” provided the concepts of an integrated PRA that results in unique PBMR end states for which source terms and any offsite radiological consequences can be calculated.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated May 31, 2002 “Submittal of Pebble Bed Modular Reactor Containment Design Position Paper,” describes how the PBMR source term will be consistent with the NRC Severe Accident Policy Statement.

EGC did not provide a PBMR source term description to the NRC during the pre-application review activities since much of the multi-module design effecting a mechanistic assessment of the source term was still under development. EGC’s preliminary assessment of the PBMR core design (i.e., limited fission product inventory and self-limiting heat generation), plant design, and fuel testing results and plans for confirmatory production fuel testing would provide the licensing basis necessary for a PBMR design where the source term would allow no offsite emergency actions to be required. The NRC did not provide any specific findings regarding PBMR source terms; however, during discussions the NRC indicated that source terms for advanced plant designs would need to be developed mechanistically.

## **Area 11 – Spent Fuel Characteristics**

The PBMR fuel waste characteristics are different than LWR spent fuel.

- EGC letter dated May 10, 2001, “Regulatory Issues Related to the Pebble Bed Modular Reactor,” provided nine white papers regarding legal and financial issues, including treatment of fuel cycle impacts relative to the PBMR.
- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 20, 2002, outlined NRC’s preliminary position regarding EGC’s white papers and NRC -identified related issues.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated November 15, 2001, “Response to NRC letter dated September 26, 2001, Regarding the Pebble Bed Modular Reactor Technical Information Availability,” provided additional information regarding PBMR spent fuel.
- NRC letter dated April 2, 2002 from Farouk Eltawila to Kevin Borton - Licensing Manager, EGC, provided the NRC’s open issues and requests toward obtaining a more in-depth understanding of fuel cycle, transportation, and waste aspects of the PBMR.

EGC provided only conceptual discussions of the PBMR on-site fuel storage, permanent disposal, and transportation of fresh and spent fuel. The NRC did not provide specific findings regarding spent fuel issues; however, the NRC provided open issues and requests for additional information. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated April 2, 2002.

## **Area 12 – Required Testing**

The NRC has proposed to revise 10 CFR 52 to, in part, address required COL prototype testing for advanced reactors similar to the current provisions for DC. This may require demonstration plants be built as a prerequisite to US COL licensing. However, the same prerequisite may apply to a full-scale demonstration plant creating an untenable situation. It is unclear whether the NRC would accept previous PBMR operating experience, or non-US NRC licensed demonstration plant experience in order to meet the proposed 10 CFR 52 rule changes.

- NRC SECY-01-0207, “Legal and Financial Issues Related to Exelon’s Pebble Bed Modular Reactor,” dated November 20, 2001, outlined NRC’s preliminary position regarding EGC’s white papers and NRC-identified related issues.

- EGC letter dated November 27, 2001, “Documents Supporting the November 30, 2001 Pre-application Meeting Regarding the Pebble Bed Modular Reactor (PBMR),” provided EGC’s position regarding testing requirements for a COL.
- EGC meeting with the NRC on November 30, 2001 provided the EGC position regarding PBMR COL testing requirements.
- NRC workshop was held on March 27, 2002 seeking additional stakeholder feedback on NRC SECY-01-0207.

EGC summarized the requirements related to testing, including the testing requirements for issuance of a COL. EGC identified that NRC regulations do not require full-scale prototype testing for issuance of a COL and the NRC previously addressed this issues during initial 10 CFR 52 rulemaking. EGC described that a substantial amount of operating experience and test data already exist on pebble bed reactors and fuel, and that EGC planed to determine whether additional tests are needed to support licensing of the PBMR using criteria that EGC would develop and present to the NRC. The NRC stated that the COL testing issue would be addressed during new 10 CFR 52 rulemaking in 2002. The NRC did indicate during discussions that a multi-module facility COL application might be viewed to be similar to a DC application due to the extended length of time over which all the modules would be constructed. The EGC position paper addressed the differences between treatment of a COL and DC application.

### **Area 13 – Operational Modes and States**

The following meetings and correspondence between EGC and the NRC were intended to familiarize the NRC reviewers with the operation of the PBMR.

- EGC letter dated November 27, 2001, “Documents Supporting the November 30, 2001 Pre-application Meeting Regarding the Pebble Bed Modular Reactor (PBMR),” provided information pertaining to the PBMR operational modes and states.

- EGC meeting with the NRC on November 30, 2001 provided a description of the PBMR operational states and a demonstration of plant operation simulations.
- NRC letter dated May 31, 2002, “Requests for Additional Information (RAI) on Analytical Codes and Software Control; Core Design and Heat Removal and; Operational Modes and States for the Pebble Bed Modular Reactor (PBMR),” provided the NRC’s open issues and requests toward obtaining a more in-depth understanding of the PBMR operation and supporting analytical computer codes.

The EGC presentation provided detailed information regarding the operation of the PBMR and the application of analytical codes used by PBMR designers to evaluate plant operation. The NRC did not provide any specific findings regarding the PBMR operational modes and states; however, the NRC provided guidance in the form of open issues and requests for clarity of the PBMR operational modes and states. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated May 31, 2002.

#### **Area 14 – Air and Water Ingress**

Gas-cooled, graphite moderated, high temperature reactors are susceptible to graphite corrosion. Chemical attack is the effect of corrosion of the graphite matrix due to water or air ingress

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, describing technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated October 23, 2001, “Documents Supporting the October 25, 2001 Pre-application Meeting Regarding the Pebble Bed Modular Reactor (PBMR),” provided information pertaining to PBMR design attributes that prevent chemical attack of graphite materials.

- EGC meeting with the NRC on October 25, 2001 providing a description of the PBMR design with regard to limiting air and water ingress.
- NRC letter dated May 31, 2002, “Requests for Additional Information (RAI) on High Temperature Materials Graphite; Control of Chemical Attack; and Design Codes and Standards for the Pebble Bed Modular Reactor (PBMR),” provided the NRC’s open issues and requests toward obtaining a more in-depth understanding of the PBMR.

The EGC presentation identified that the fuel integrity is maintained during all operating and design basis accident conditions including chemical and other physical attack on the fuel. The EGC letter discussed the safety design approach to controlling any chemical attack in terms of prevention and mitigation of off-normal events with either water or air ingress. The NRC did not provide any specific findings regarding the PBMR design in regard to graphite corrosion; however, the NRC provided guidance in the form of open issues and requests for information. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated May 31, 2002.

#### **Area 15 – In-Service Inspections (ISI)/In-Service Testing (IST)**

The PBMR on-line refueling capabilities, maintenance outage schedules, and material service conditions may present new and perhaps unique in-service inspection and testing programs and/or methods.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- NRC letter dated May 31, 2002 “Requests for Additional Information (RAI) on High Temperature Materials Graphite; Control of Chemical Attack; and Design Codes and Standards for the Pebble Bed Modular Reactor (PBMR),” provided the NRC’s open issues and requests toward obtaining a more in-depth understanding of the ISI and IST programs for the PBMR.

EGC did not provide details regarding ISI or IST plans since this information was in the very preliminary stages of development. The NRC provided guidance in the form of open issues and requests for information. As explained above, EGC will not respond to the NRC RAI contained in the NRC letter dated May 31, 2002.

## **Area 16 – Containment**

The PBMR containment is designed specifically for the high temperature gas-cooled reactor. NRC policy regarding containment design would need to be assessed regarding its applicability to gas-cooled reactors, and the PBMR design.

- NRC letter dated September 26, 2001 from T. L. King to J. Muntz - Vice President, EGC, described technical areas the NRC would like to cover during pre-application review of the PBMR.
- EGC letter dated May 31, 2002, “Submittal of Pebble Bed Modular Reactor Containment Design Position Paper,” provided EGC’s preliminary position regarding the PBMR containment design relative to NRC regulatory policy.

EGC provided a position and initial approach to address the PBMR containment design relative to applicable NRC regulatory policy. EGC concluded the preliminary PBMR containment design would meet the latest NRC policy regarding containment since the policy focuses on containment function rather than specific design aspects. The PBMR containment design can be shown to provide components or systems that can inherently or passively protect separate multiple barriers from the potential release of radioactive material to the environment. Finally, it can be demonstrated that the PBMR containment design is consistent with the Severe Accident Policy Statement. The NRC was not requested by EGC to respond to the EGC position since EGC has discontinued participation in the PBMR development process, and the purpose of the paper was

intended to be a guide for future NRC pre-application interactions regarding a containment policy if PBMR licensing activities were to be resumed.